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Consideration of the key issues of energy for sustainable development, with due consideration given for each issue to the means of implementation: capacity-building, technology transfer and financial resources

Energy and sustainable development: options and strategies for action on key issues

Report of the Secretary-General

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Introduction

1. At its nineteenth special session, the General Assembly emphasized that, in line with the objectives of Agenda 21,[1] the ninth session of the United Nations Commission on Sustainable Development, to be held in April 2001, should contribute to a sustainable energy future for all.[2] Specifically, for the ninth session of the Commission, the Assembly decided, inter alia, (a) that the sectoral theme to be discussed would be atmosphere/energy and the economic sector to be discussed would be energy/transport[3] and (b) that preparations for that session of the Commission should be initiated at its seventh session and should utilize an open-ended intergovernmental group of experts on energy and sustainable development, the sessions of which were to be held in conjunction with inter-sessional meetings of the eighth (2000) and ninth (2001) sessions of the Commission.[4]

2. At the first session of the Ad Hoc Open-ended Intergovernmental Group of Experts on Energy and Sustainable Development, discussions took place on the report of the Secretary-General entitled "Energy and sustainable development: key issues" (E/CN.17/ESD/2000/3) of 1 February 2000, on the basis of which several key issues pertaining to energy and sustainable development were identified for more detailed discussion at its second session to be held in February 2001. The key issues highlighted in the report of that session (E/CN.17/2000/12) of 27 March 2000 for consideration at the ninth session of the Commission were: accessibility of energy, energy efficiency, renewable energy, advanced fossil fuel technologies, nuclear energy technologies, rural energy, and energy and transportation. In relation to each of these key issues, the Group of Experts emphasized that the following overarching issues should receive serious consideration by the international community: technology transfer, capacity-building, mobilization of financial resources, and international and regional cooperation.

3. The present report focuses on the challenges confronting energy for sustainable development and on the various issues that need to be addressed in order to progress towards a sustainable energy future for all. The report discusses several options for addressing these issues, including several specific actions that are needed at the national, regional and international levels. Also discussed are options for improving coordination of United Nations system-wide efforts aimed at assisting developing countries in their domestic efforts to develop the energy sector in a sustainable manner.

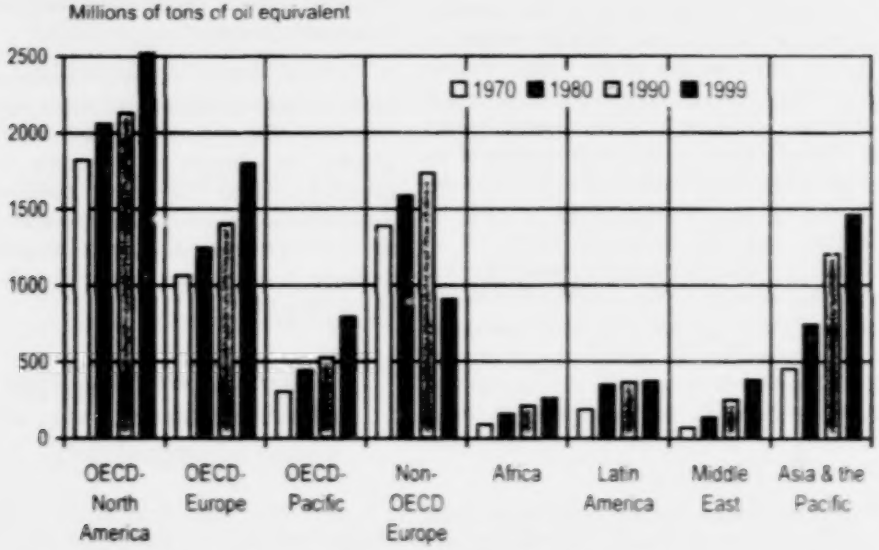
4. As a preface to the presentation of the various options and strategies for each key issue, a brief overview of world energy production and consumption patterns and trends is presented to underscore the growing concern that current patterns of fossil energy consumption in industrialized countries together with the anticipated rapid growth in demand for energy services in developing countries may be unsustainable in the long term.

I. Trends in world energy production, distribution and use, and concerns about sustainability

5. In 1999, the total world commercial primary energy consumption amounted to 8,534 million metric tons of oil equivalent (mtoe). Petroleum (crude oil and natural gas products) continued to be the world's dominant primary energy source, accounting for almost 40.6 per cent of the total. Coal ranked second as a primary energy source, accounting for 25 per cent of world primary energy consumption. Dry natural gas ranked third as a primary energy source, accounting for about 24 per cent. Electric power generation from nuclear, and from hydro and other renewable sources (including solar, wind, biomass, and geothermal), accounted for 7.6 per cent and 2.8 per cent, respectively.

6. Total world commercial primary energy consumption during the 25-year period from 1975 to 1999 registered an average annual growth rate of about 1.6 per cent. During this period, nuclear power exhibited the highest annual growth rate, about 8.4 per cent, followed by natural gas, about 2.6 per cent; hydro, about 2.5 per cent; crude oil, about 0.96 per cent; and coal, about 0.89 per cent.

Total primary commercial energy demand by region, 1970-1999



Source: Department of Economic and Social Affairs of the United Nations Secretariat, based on United Nations, *Energy Statistics Yearbook*, various issues; *BP Amoco Statistical Review of World Energy*, June 1999; Energy Information Agency, United States Department of Energy, *International Energy Outlook, 1999*, March 1999; and International Energy Agency, Organisation for Economic Cooperation and Development (OECD), *World Energy Outlook* (Paris), various issues.

7. Comparisons of commercial primary energy consumption by region, shown in the figure, highlight key energy trends since 1970. With the exception of the non-OECD (Organisation for Economic Cooperation and Development) Europe region, substantial growth in total commercial primary energy demand was recorded for all regions and economic groups of countries from 1970 to 1999. The non-OECD Europe region registered a large decline in its primary energy consumption over the past decade. The OECD-North America countries continued to lead in total commercial primary energy demand, with a 1999 energy consumption of about 2,557 mtoe; in comparison, the total demand of developing countries was about 2,550 mtoe. Primary energy demand continued to increase in both the OECD-Europe and OECD-Pacific regions, with the latter exhibiting higher growth. In Latin America, primary energy demand between 1991 and 1999 exhibited an average annual growth rate of about 3 per cent, while in the Middle East and the Asia and the Pacific regions, the total primary energy consumption increased on average about 2.5 per cent annually.

8. Large differences exist in total commercial primary energy demand for the different regions and groups of countries, both in absolute terms and on a per capita basis. In the one-year period 1998-1999, the total primary energy demand of developing countries registered a decline of about 2.3 per cent, in the aftermath of the Asian economic crisis. The growth of 1.4 per cent in the OECD countries, which account for almost 60 per cent of total world demand, was in line with the trend of the past decade. The per capita consumption of commercial primary energy in developing countries is one tenth of that in OECD countries; in 1999, it was about 0.62 tons of oil equivalent per year (toe/yr) compared with 6.4 toe/yr for the OECD countries. In the Sahel region of Africa, per capita consumption of commercial primary energy was only 3 per cent of that in OECD countries.

9. Nearly 2 billion people, mostly living in rural areas of developing countries, still do not have access to commercial energy. If the goal of poverty

eradication is to be achieved, the energy needs of these people will have to be urgently addressed.

10. Moreover, although energy plays a key role in economic and social development, the current patterns of production and use also carry negative externalities. These negative effects are sometimes local but generally occur far from the place and long after the time energy is produced and used. As a consequence, market forces do not necessarily orient economic actors towards socially and economically optimal solutions. Furthermore, because energy use affects all sectors of economic activity, this aspect of market impact occurs globally.

11. The iniquitous consumption of energy that exists in the world today is also not compatible with the goal of attaining a sustainable energy future for all. The impact of energy production and use on environmental quality, health and climate change is well described in the World Energy *Assessment* (September 2000) published in New York by the United Nations Development Programme, the Department of Economic and Social Affairs of the United Nations Secretariat and the World Energy Council. The message from that report is that the risk of climate change is high and the already existing serious adverse effects on environmental quality and human health will be further exacerbated if present patterns of energy production and use are continued. Even taking into account increased use of renewable sources and vastly improved energy efficiencies, consumption of fossil fuels will actually grow over the next 10 to 20 years. Thus, new approaches are needed to effect a shift to sustainable energy paths in the coming decades.

II. Key issues: options and strategies for action

12. Policy actions for effecting a change of course from the present paths to sustainable energy paths basically rest with Governments. Because energy production and use have major positive as well as negative externalities, government action to ensure equitable access to energy not only constitutes a basic element of the effort to combat poverty, but also is key to the development of economic activity and the welfare of citizens. In addition, because of negative effects on the environment and health, government action is needed to orient market forces towards environmentally optimal solutions. While the basic responsibility for sustainable energy policies rests with Governments, a participatory approach involving all relevant stakeholders could facilitate progress. Because energy is an area with strong interdependencies among countries, international agreement is essential for reaching a consensus not only on shared goals of action but also on the framework for regional and international cooperation. The way in which energy issues are addressed in a country depends on the national energy situation. Therefore, a range of options with corresponding policy goals and strategies becomes necessary to address the issues involved. Accordingly, a number of options and strategies for action that could effect a change in the way energy is dealt with are delineated in this report. The choice of any specific action would obviously depend on the domestic situation.

13. In the Programme for the Further Implementation of Agenda 21 adopted by the General Assembly at its nineteenth special session,[5] emphasis is placed on the critical importance of mobilizing much needed investments for sustainable energy development in developing countries. In these countries, consumption of energy and energy services will have to increase sharply if their development objectives are to be achieved. Creating the necessary enabling environment for promoting investments in energy by domestic as well as foreign investors through appropriate policies is critically important for Governments. Concrete actions are needed to achieve this important objective as well as those relating to the strengthening of institutional and human resource capacities in these countries. The development and transfer of sustainable energy technologies and systems to developing countries also constitute an important and integral part of proposals for action.

14. The linkages between energy and other major global issues occur at a number of levels. At one level, there is a need to address the issue of meeting the basic energy needs of low-income populations, especially in the least developed countries. At another level, there is a need to address, in a comprehensive manner with due consideration to environmental and health aspects, the issue of the challenge being faced by most developing countries of sustaining the rapid increases in energy supplies and energy services required for their development. Also, in looking at the energy requirements of small island developing countries,

account needs to be taken of their diversity with respect to their economies, geographical location, weather regimes, environmental fragility and vulnerability to natural disasters, so that options will fit their specific requirements. At yet another level, it is equally important to address the issue of energy security and market stability, as well as the issue of meeting the long-term global demand for energy. Energy security issues have to be viewed with respect to supply-side, as well as demand-side, concerns.

15. Policy options and strategies need to take account of the considerable diversity that exists within each country as well as among different countries. Such diversities can occur in terms of the resource endowment, the demand for energy services and the structure of energy supply, institutional and human resource capabilities for policy formulation and implementation, access to technologies and capital, and sociocultural setting. Therefore, given the interdependencies and complexities inherent in energy issues, a broad range of actions are needed at the national, regional and international levels to address energy for sustainable development.

16. The underlying principles guiding the approach to energy for sustainable development are embodied in the approach that seeks to promote the efficient production and use of energy, wider-scale use of renewable sources, and transition to the next generation of fossil fuel and nuclear energy technologies. The international community can facilitate the movement from the present energy system to a more sustainable one by supporting capacity-building, technology transfer and investments in developing countries and, at the same time, by encouraging full implementation of the commitments of industrialized countries on greenhouse gas emission reduction. An international framework and associated implementation mechanisms would be helpful in promoting this effort.

17. It is estimated that investment capital of US$ 100-300 billion per year for the next 20 years is required in developing countries to meet the current shortfall in energy demand. Furthermore, in order for the developing countries to replace less efficient energy systems with more efficient next-generation energy technologies, significantly greater investment capital will be needed. Against this scenario, the commitments of the World Bank group in the energy sector during fiscal years 1995-1998 amounted to an average of US$ 3.5 billion per year. Thus, the development and deployment of sustainable energy technologies and services in developing countries will be a major challenge in the near to medium term. Official development assistance (ODA) to developing countries continues to be important even though financing of energy infrastructure projects in countries with developing and transitional economies has been shifting from Governments, State-owned utilities and multilateral financial institutions to domestic and international private financial firms and energy companies. This shift is primarily attributable to energy sector reforms. Governments are expected to play an increasing role in setting policy and developing laws and regulations for the sector, while the private sector is expected to increase financing, and build and manage the energy infrastructure.

18. The options and strategies, as well as their principal implications, discussed in this report are intended to facilitate further discussions of the key issues, each of which may have several technical, social, economic and environmental dimensions and may present diverse challenges. Response to those challenges requires actions at the national, regional and international levels.

A. Accessibility of energy

Challenges to improving accessibility of energy

19. Access to energy is crucial to economic and social development, and alleviation of poverty. Improving accessibility of energy implies finding ways and means by which energy services can be delivered reliably, affordably and in an environmentally sound and socially acceptable manner, particularly in meeting the energy requirements of developing countries, including their rural areas. Section F, below, will focus specifically on the challenges to, and the options and strategies for, providing energy to rural areas.

20. Furthermore, accessibility of energy is conditioned by security of supply and demand as well as by market stability, all of which need to be addressed in terms of their regional and international dimensions, which include cross-border energy transport infrastructure, storage, and shipment by tankers.

21. Although concern about security of energy supplies is not as intense today as it was in the 1970s and the early 1980s, the availability of future supplies

of oil and natural gas continues to preoccupy Governments in countries heavily dependent on imports. Oil imports of a number of industrialized as well as developing countries are as high as 50 per cent of their total energy consumption and are likely to rise further over the next decade. At present, around 30 per cent of world oil consumption is supplied by the countries of the Middle East. Moreover, the world's dependency on oil from Organization of Petroleum Exporting Countries (OPEC) members is projected to rise to 50 per cent by 2010. Many factors impinge on the world oil price movement, as the recent interplay between supply and demand has demonstrated. Security of gas supplies could become more critical over the long term as the expected growth of natural gas consumption in many countries will inevitably boost import dependency in those countries. As Governments take measures to open up and liberalize natural gas markets, new forms and ways of supporting the development of large additional supply projects, as well as further upstream and downstream integration, mergers, acquisitions and strategic alliances, could take shape. The full implications to energy security of these developments are unpredictable at this stage. The challenge to enhancing energy security lies in diversifying the energy mix available to consumers.

22. Thus, challenges to improving accessibility of energy include: (a) the lack of requisite capacity at national and local levels to address the enormous magnitude and scale of poverty in most developing countries, particularly in rural areas without access to modern energy services to meet their basic and development needs; (b) the frequent supply and demand imbalances, and consequent market instability resulting from inadequate information exchange and international dialogue between producers and consumers of energy on supply and demand issues, and inadequate attention to lead times required for developing new oil or alternative supplies, as well as upstream replacement investment in the public sector; (c) the technical, economic, social and political challenges to expanding the supply of electricity to the large population in rural areas that are still without access; (d) the unique and diverse set of conditions that impinge on energy supply and energy security faced in a number of small island States; and (e) the barriers to such cross-border arrangements as interconnection of electric grids, cross-border gas pipeline grids, regional underground oil and gas storage, and trade and transit agreements for transportation of energy products, including shipment by tankers, all of which also have regional and international dimensions.

Options and strategies to improve accessibility of energy

23. At the national level, focus on satisfying the energy needs of the poor with modern fuels and technologies has the potential to improve standards of living and health, and create new jobs and business opportunities. Addressing the energy needs of the poor in developing countries will require not only major macroeconomic changes, but also targeted social policy actions that will make commercial energy more widely available. For the rural populations in many parts of the developing world that continue to be heavily dependent on fuelwood and other biomass resources, options that could be considered are: (a) improving access to sustainable biomass and fuelwood supplies, and commercializing biomass operations, including the use of agricultural residues; (b) progressively shifting to liquid and gaseous fossil fuels; (c) developing locally available energy resources for greater energy security through diversification; and (d) supporting electricity services based on grid extension and/or decentralized energy technologies.

24. Option 23 (a) above implies that national and local level actions are needed to promote: (i) fuelwood conservation measures, (ii) more effective use of agricultural residues, (iii) the cultivation of fast-growing species of plants and (iv) the use of modern technologies for the conversion and efficient utilization of biomass, including the use of improved stoves, biogas and solar cookers in households for cooking. Option 23 (b) implies less dependence on biomass through improved access to liquid and gaseous fossil fuels by households, particularly in rural areas. This will have a major effect in reducing indoor air pollution and improving the health of women and children. Such a shift will require economic liberalization policies that would make possible wholesale and retail marketing of these fuels and that would also promote the sale of corresponding appliances by entrepreneurs. Option 23 (c) implies policy support for the development and utilization of local energy resources, particularly renewable resources that can improve accessibility of energy. This action can also reduce burdensome dependence on imports, thereby contributing to greater energy security. Option 23 (d) emphasizes the electrification of

rural areas through grid extension or development of local grids with decentralized alternatives to improve the accessibility of electricity services.

25. Lack of adequate and reliable supplies of electric power is a major constraint on economic and social development in many parts of the developing world. Policy options lie in creating an enabling environment for the private sector or energy cooperatives to engage in the generation and distribution of electricity on a commercial basis including decentralized electrification solutions based on solar, wind, biomass or small hydro alone or in combination with non-renewable alternatives.

Actions relevant to overarching issues

26. Actions are needed at the national level to strengthen the capacity of community-based organizations and institutions, including women's groups, to facilitate participatory approaches to energy for sustainable development. As part of this capacity-building effort, assistance needs to be provided in the form of information resources, organizational support, training, planning and management tools, and entrepreneurial skills so as to facilitate access to modern energy services. The international community can play a vital role in catalysing further targeted action at the national level so that the global problem of there being 2 billion people still without access to modern energy services could receive much-deserved attention. Building local capacity is also vital for the development of local energy resources and deployment of decentralized energy systems, thereby enhancing energy security.

Options and strategies for international and regional cooperation

27. At the regional level, actions that can be considered are: (a) the development of regional cooperative arrangements for increased regional energy trade in fuels and electricity, and investments in energy infrastructure, thereby improving accessibility; (b) the creation of institutional arrangements and regulatory mechanisms for promoting the interconnection of electric grids; (c) the establishment of dialogue forums between regional producers and consumers for enhancing regional trade; and (d) the promotion of regional storage facilities to address short-term fluctuations in energy market situations.

28. New initiatives may be needed at the international level to improve accessibility. One option is to establish a mechanism for facilitating the exchange of information on supply and demand between producers and consumers of energy with the goal of increasing market stability.

B. Energy efficiency

Challenges to energy efficiency improvements

29. The fact that improving energy conversion and end-use efficiency can lead to a reduction of the energy consumption per unit product or activity provides a compelling basis for policy initiatives and actions. Making the energy system more efficient contributes to improving local air quality and health, and to reducing regional acidification, and offers considerable potential for greenhouse gas reduction. Energy efficiency improvements also reduce the investment requirements of the energy sector for any given level of gross domestic product (GDP). Barriers to achieving a significant portion of the energy efficiency potential involve both market-related and institutional issues. Current functioning of markets does not lead economic actors to choose energy efficient products and services; the institutional barriers discourage energy institutions from promoting energy efficiency.

30. *Market challenges and barriers.* Market challenges and barriers include: (a) a weak enabling environment for energy efficiency investments by the private sector, including unrationalized tariff pricing structures, inadequate legal and regulatory frameworks, and lack of fiscal and financial incentives; (b) inadequate participation of private sector energy service companies in promoting energy efficiency investments; (c) low consumer awareness of the benefits of energy-efficient technologies and practices; (d) lack of information on energy use and options for efficiency improvement from which consumers can make rational decisions; (e) little apparent consumer interest in buying energy-efficient technologies or adopting such practices (attributed to lack of understanding of new, energy-efficient technologies and their cost-effectiveness); (f) limited access to investment capital and/or reluctance to commit capital to energy efficiency projects offering two- to three-year payback periods; (g) risk-aversion towards investing in new technologies; (h) inadequate maturity of the market infrastructure, manifested primarily in poor

availability of efficient equipment and skilled service people to install and maintain the equipment; (i) less-than-optimal decision-making in investments on capital and consumer goods, since life-cycle costs are not considered; (j) least-cost bidding procedures in enterprise investment decisions, which do not lead to the purchase of energy-efficient systems; and (k) the diffuse nature of the responsibility for energy efficiency incorporated within enterprises.

31. *Institutional challenges and barriers.* Institutional challenges include: (a) the lack of explicit national policies for energy efficiency at the end-use level; (b) the incomplete transition to cost-based electric tariffs for residential, commercial and industrial customers; (c) inadequate institutional oversight for energy utilization; (d) the limited credit available in financial institutions and the national economy; and (e) the lack of application of modern management skills in public sector enterprises and lack of adequate technical expertise as regards energy efficiency.

Options and strategies for more efficient energy systems

32. *General.* At the national level, one of the principal options in the short and medium terms is to intensify efforts on the part of all stakeholders, including Government, industry and consumers, using relatively simple measures, such as better housekeeping and energy management, that improve energy efficiency at the point of end use. This can result in energy savings of as much as 20-30 per cent. For the long term, however, groundwork needs to be laid to introduce new and more efficient technologies and practices. Action elements include: (a) the mobilization of stakeholders through the introduction of information- and awareness-building activities; (b) the establishment of an enabling environment for wider-scale market participation of private sector energy service companies (ESCOs) to promote investments in energy efficiency; (c) business development support to companies interested in entering or expanding the energy service business; (d) the development of improved codes and standards for efficient energy use by new equipment and buildings; (e) the establishment of testing laboratories and international test protocols for energy-efficient equipment; (f) the institutionalization of learning and information in power sector planning; (g) the development and execution of national energy efficiency strategies; (h) the provision of incentives (for example, technical support, preferential credit and tax exemption) to achieve specified targets of energy conservation; (i) the sensitization of financing institutions to the costs/benefits of energy efficiency investments; and (j) assistance to ESCOs in adequately assessing risk in funding proposals to address the concerns of financial institutions.

33. *Industrial and commercial sectors.* Options in this category include: (a) the establishment of mandatory building codes for the energy-efficient design and operation of commercial buildings; (b) the minimization of heat and power losses and the expanded use of waste heat recovery technologies and automated process controls; (c) the greater use of cogeneration; (d) the establishment of mandatory performance standards for energy-consuming equipment; (e) the replacement of outdated, inefficient industrial equipment and processes by modern, more efficient equipment and processes; and (f) the adoption of state-of-the-art processes and technologies in new industrial undertakings.

34. *Residential sector.* Options in this category include: (a) the adoption of mandatory standards and application of professional codes of practice for energy-efficient design in new residential buildings; (b) retrofitting existing homes with energy efficiency measures; (c) the development and promotion of energy efficiency standards and labelling for major energy-consuming equipment and appliances; and (d) the publicizing of good housekeeping energy management practices using public media.

35. *Transport sector.* Options in this category include: (a) the development and promotion of more efficient vehicle technologies; (b) the introduction of vehicle fuel consumption labelling schemes; (c) city planning and land-use policies that reduce the need for transport of goods and passengers, traffic flow controls and handling in cities that encourage reduced fuel consumption, and road design; and (d) the promotion of transport modal shifts from road transport to energy-efficient rail, water and multimodal systems, and from private vehicles to public transportation.

36. *Power sector.* Options in this category include: (a) the development of a self-sustaining power sector through reappraisal of the roles of Government and the private sector and sector reform towards a commercial orientation and the elimination/reduction of electricity

price subsidies; (b) the improvement of the thermal efficiency of electricity generation through the adoption of new coal technologies; (c) the utilization of hydropower resources to the fullest extent, recognizing the potential of this option for cheap, clean electricity, provided environmental and social issues are adequately addressed; (d) the upgrading of the power transmission and distribution networks and employment of loss reduction measures; and (e) the introduction of appropriate tariff structures to entice consumers to shift their demand from peak times through better load management.

Actions relevant to overarching issues

37. The capacity to undertake the full range of actions identified above requires a national commitment to strengthening existing institutions engaged in energy efficiency activities or to establishing new ones and to providing training for this purpose. Developing countries will need, in addition to their own efforts beginning with awareness campaigns and the establishing of information resources, assistance from outside to strengthen their institutional and human resources capacities. While in the short and medium terms assistance can take the form of information tools, good practices including demand-side management, and training, for the longer-term transition to sustainable energy systems the transfer of relevant technologies will be of crucial importance. Appropriate economic and institutional reforms would be required in developing countries to encourage private sector involvement that can attract investments in more efficient energy technologies.

Options and strategies for international and regional cooperation

38. Options at the regional and international levels include: (a) the establishment of information management and dissemination capabilities to provide information to the energy service industry on market opportunities and energy efficiency infrastructure and information to consumers on the benefits of energy efficiency measures; (b) the fostering of regional and international cooperation in undertaking research and development on energy efficiency that is oriented to new, efficient energy technologies; (c) funding support for a research and development programme; (d) the creation of an Internet-based web site containing databases on energy efficiency options as an information clearing house serving all countries; (e) international cooperation between industrialized and developing countries in capacity-building for energy efficiency; and (f) the establishment of regional and/or international training centres for energy efficiency.

C. Renewable energy

Challenges facing renewable energy development and utilization

39. While renewable energy is generally widely accepted, the main challenge lies in the development and utilization of renewable energy technologies on a scale wide enough to impact on the energy situation nationally and globally. Despite some progress in promoting renewable energy applications in recent years, numerous constraints and barriers continue to exist, although some have been lowered during the past two decades. Actions initiated by both Governments and international agencies to remove them over the past two decades have not been commensurate with the scale of effort needed to mainstream renewable sources into the energy sector.

40. Challenges confronting renewable energy development and utilization include: (a) the low priority given to renewable energy development in national energy planning and policy development; (b) the uneven playing field due to subsidies for conventional energy systems (including direct and indirect fuel subsidies); (c) the lack of commensurate institutional arrangements; (d) the lack of awareness of technologies, as well as of their economic and social benefits; (e) the inadequate support for technology development; (f) the market uncertainties and constraints regarding access to technologies; (g) the non-uniform and discouraging levels of import duties and other levies; (h) the high upfront cost of renewable energy systems; (i) the high transaction costs of smaller-scale projects; (j) the lack of financing and credit arrangements; (k) the inadequate development of standards and best practices for all renewable energy systems; (l) the lack of manufacturing infrastructure; and (m) the paucity of skilled human resources.

Options and strategies for increasing the use of renewable energy

41. Evidence for the need to increase the share of renewable energy in the overall energy mix is provided by the scenarios in the World Energy Assessment, which demonstrates that renewable energy has a significant role to play in practically all plausible scenarios that lead to a sustainable energy future.

42. The creation of an enabling policy environment, with appropriate institutional arrangements at the national level, constitutes a key option for the accelerated development and wider-scale application of renewable energy. The experience of some countries that have established separate ministries, government departments or agencies dedicated exclusively to renewable energy indicates that such action has invariably spurred a variety of policy initiatives and catalysed nationwide activities. An institutional focal point at the national level, with its counterparts at decentralized levels, is conducive to decision-making, including the speedy clearance of projects which accompanies a single-window approach. Such action also enables a country to evolve a coherent and coordinated approach with the involvement of relevant entities in the public and private sectors, and with non-governmental organizations.

43. Policies that incorporate attractive incentives have been found to play a catalytic role in the "market pull" effect for renewable energy systems. Practical options for increasing the share of renewable energy can take the form of: (a) direct capital subsidies, which can eventually be phased out; (b) financial incentives to users, project developers and manufacturers; (c) economic and legislative measures; (d) tax credits; (e) exemptions from the payment of customs duties, and excise and sales tax; (f) preferential pricing of electricity produced from renewable sources; and (g) arrangements for the banking, wheeling and buy back of electricity from independent power producers. Other legislative measures include: (a) laws that require all new buildings to incorporate energy-efficient features and renewable energy systems, especially solar passive and active heating and cooling systems; (b) a renewable non-fossil fuel obligation requiring that electric utilities have a minimum percentage of their supply mix from renewable sources; and (c) concession contracts for rural electrification competitively tendered to ESCOs.

44. The introduction of innovative financing and credit schemes, including concessional loans to users as well as to manufacturers, is an option that can provide the needed impetus for the expansion of renewable energy applications. A number of innovative financing options have emerged in recent years aimed at overcoming the barriers faced in attempting to commercialize renewable energy technologies.

45. Renewable energy applications are still at a nascent stage, but are likely to expand with technological improvements. There is general concern that efforts in the research and development of cost-effective renewable energy technologies are inadequate. Options in this regard include: (a) intensifying national research and development efforts with greater government commitment and support; (b) fostering regional and international cooperation through joint research projects and networks of research institutions; (c) investing of a greater share of the resources of large companies in the public and private sectors to accelerate research efforts; and (d) supporting entrepreneur development and commercialization efforts including ESCOs. Another strategy with regard to technology is the acquisition, adaptation and absorption of available technologies through technology transfer mechanisms. There are already a variety of technologies that are mature, cost-effective for certain applications and available on the market. Developing countries would find it easier to adopt options to purchase or develop renewable energy systems if a significant number of demonstration or pilot projects were first undertaken with appropriate local participation followed by evaluation.

Actions relevant to overarching issues

46. Because renewable energy is a relatively new area of activity, there is a serious need in developing countries for capacity-building and technology transfer initiatives that can improve the availability of renewable energy systems and enhance local skills to enable trained personnel not only to better maintain and service equipment, but also to engage in its manufacture. Research and development, as well as design and project engineering capabilities — which might involve not only the establishment of appropriate facilities but also training activities — need to be strengthened. Therefore, action aimed at strengthening institutional capabilities is urgently needed, especially at the local level, to facilitate the work of the public

and private sectors, as well as that of non-governmental institutions in many parts of the developing world. In this context, the agricultural extension model that catalysed the green revolution in some developing countries can serve as an example for initiating concrete institutional development activities for the extension of renewable energy applications. International support for capacity-building in developing countries is vital especially in Africa.

Options and strategies for international and regional cooperation

47. At the international level, complementary options for achieving an increased contribution from renewable energy include: (a) promoting freer trade in renewable energy devices and systems; (b) facilitating technology transfer agreements on easier terms; (c) supporting national efforts to build organizational and manufacturing capacity for the diffusion of renewable energy technologies; (d) innovative financing and credit mechanisms; and (e) mobilizing private sector investment. Also to be considered are ways and means of strengthening the linkage between existing international mechanisms such as the Global Environment Facility (GEF), and renewable energy development and utilization. New mechanisms to be considered include: (a) initiating international energy forums for dialogue on global issues and (b) establishing regional and international networks of centres of excellence for the development and diffusion of renewable energy technologies. For effective regional cooperation, the options to be considered include: (a) forums for the exchange of experiences in the development and application of renewable energy, (b) research and development cooperation, including joint development projects, (c) the sharing of testing and training facilities and (d) South-South cooperation in subregional and regional programmes for capacity-building.

D. Advanced fossil fuel technologies

48. Even taking into account the potential of a significant increase in the use of renewable fuels and vastly improved energy efficiencies, the contribution of fossil fuels in the world energy supply will actually grow, not decline, over the next 10 to 20 years. Thus, the achievement of a sustainable energy future will require the successful development and deployment of advanced fossil fuel technologies that boost efficiency and sharply reduce environmental impacts, at affordable costs. A transition to the next generation of fossil fuel technologies that can significantly reduce emissions will be necessary to stabilize the atmospheric concentrations of greenhouse gases. However, no single technology appears to have the potential to provide the emission reduction necessary to stabilize such atmospheric concentrations. Thus, a wide range of technologies will be needed, with local circumstances determining the choice of technology to be adopted.

Challenges facing the development and deployment of advanced fossil fuel technologies

49. The principal challenges in promoting applications of advanced fossil fuel technologies are: (a) creating an awareness of advanced fossil fuel technology options in order to achieve a reduction of greenhouse gas emissions from fossil fuel combustion and their eventual elimination in order to stabilize atmospheric greenhouse gas concentrations; (b) mobilizing support for the further development of advanced energy technologies aimed at a significant reduction of greenhouse gases (near-zero emission technologies); (c) transferring advanced energy technologies to developing countries and building the requisite capacity for their assimilation; and (d) mobilizing the investments required for a shift to the next generation of cleaner fossil fuel technologies that are considered to be substantially more advanced, and efficient, and that produce a very low level of greenhouse gas emissions.

Options and strategies to introduce advanced fossil fuel technologies

50. Given the magnitude of carbon emission reductions needed from fossil fuel combustion to stabilize the atmospheric carbon dioxide (CO_2) concentration, multiple approaches to carbon management will be required. There are primarily three such approaches that are being considered and implemented. The first approach is to increase the primary energy conversion and end-use efficiencies so that fewer units of primary fossil energy are required to provide the same energy services, in other words, lower CO_2 emission per unit of energy service. To this end, more efficient fossil fuel-fired power plants, buildings, appliances and transportation vehicles are being

developed and used. The second approach is to substitute fuels containing less carbon or carbon-free sources for the current fossil fuels, such as natural gas for coal or oil. The third approach is carbon sequestration which, although distinguished from the first two approaches, complements them and has recently received considerable attention.

51. Advanced technologies for coping with the challenges posed by fossil fuels are described in the World Energy Assessment, which analysed, in detail, advanced fossil fuel technologies for the generation of power and combined heat and power, advanced fuels for transportation, decarbonization and CO_2 sequestration. It also provides a technical review of CO_2 abatement technologies to increase the efficiency of coal use and to facilitate CO_2 capture.

52. Coal, which accounts for about 26 per cent of world primary energy consumption and is mainly used to fire electric power plants, is a fossil fuel that can be made cleaner. Currently, the alleviation of environmental impacts from electricity generation has been mainly confined to the mitigation of acid rain precursors (sulphur dioxide (SO_2) and nitrogen oxides (NO_X)), particulate matter, fly and bottom ash, and some other pollutants. Emissions of greenhouse gases, particularly CO_2, are generally not regulated, except in some countries of Western Europe. Significant greenhouse gas emission reductions may be achieved using clean coal technologies that increase the net efficiency of coal-fired power stations, so that less CO_2 is emitted per unit of electricity generated. The net plant efficiency of coal-fired power generation in OECD countries averages about 36 per cent, with about 45 per cent efficiency achievable with supercritical pulverized coal and combined-cycle technologies. In non-OECD countries, net plant efficiency of coal-fired power stations is lower than these values. Efficiency gains of 5 to 10 per cent are possible through the renovation and servicing of the power plants, depending on the operating condition prior to servicing. With increasing concern over the local, regional and transboundary effects of air pollution, including health problems, legislation on air pollution is being introduced or is being made more stringent around the world. Such legislation will have consequences for existing and new coal-fired power plants and therefore advanced clean coal technologies are under consideration in many countries with developing and transitional economies. Their wide-scale commercial application will largely depend on international demonstrations and technical and financial cooperation. Thus, there are major opportunities for international cooperation in improving efficiency and emission reductions.

53. Natural gas is the cleanest fossil fuel and, when used in combined-cycle power plants, is the primary fuel of choice for generating electricity today. At the core of the combined-cycle plant is the gas turbine. Much progress has been made in the design of gas turbines, including features vastly superior to the gas turbines now in use. The fact that the high operating temperature in an advanced gas turbine is 150 Celsius (300 Fahrenheit) degrees hotter than that in a conventional gas turbine boosts the former's power generating efficiency. Design innovations also reduce NO_X pollutants by at least half when compared with the best utility turbines available today.

54. The fuel cell is an even cleaner technological option for extracting energy from hydrogen or hydrogen-rich gas from natural gas, gas made from coal, or practically any other hydrocarbon source. Currently, a major constraint on the more widespread use of fuel cell systems is that large-scale production and distribution infrastructures do not exist for the hydrogen fuel. An extensive transportation, storage and distribution network for hydrogen would require a very large investment. However, distribution systems for some possible sources of hydrogen are already in place, namely the distribution systems for natural gas, motor gasoline and diesel fuel, and, to a lesser extent, for liquid petroleum gas and methanol. Fuel reformers can generate high-purity hydrogen from hydrocarbon fuels during intermittent demand cycles; however, they must be able to do so without sacrificing the high-efficiency power generation obtainable from fuel cells. A fuel cell system is ideal as a distributed power source, as it can be sited close to the electricity user, whether an electrical substation, a housing centre or a remote village. Dispersed systems may be impractical in countries, or regions within countries, of rapidly growing power demand, but could be used as supplemental power sources. Given the considerably higher efficiency and very low emissions of fuel cells compared with internal combustion engines and turbines, the use of fuel cells as power units in motor vehicles can greatly mitigate the environmental impacts of the transportation sector, which continue to be very large. There is a distinct advantage if gasoline

is re-formed to produce hydrogen for vehicles because it is readily available worldwide, thereby making possible the widespread adoption of the fuel cell as a practical power source in the near term. An alliance of a number of leading automobile manufacturers has set 2004 as the target year for the introduction of a commercial automotive fuel cell and drivetrain system.

55. Carbon sequestration appears to be an important technological option for the future control of CO_2 emissions. While carbon sequestration in underground reservoirs has been demonstrated, many important questions remain concerning cost, applicability in diverse areas, the availability of environmentally acceptable reservoirs for CO_2, and the ability of reservoirs to safely retain CO_2. Although the cost of capture is often considered to be a major inhibitor to the wide-scale application of CO_2 sequestration, recent estimates show that carbon gases could be captured and sequestered for about US$ 10 per ton of carbon, which is equivalent to adding about two tenths of one US cent per kilowatt-hour to the cost of electricity.

Actions relevant to overarching issues

56. Advanced fossil fuel technologies involve infrastructure and skills that do not exist in many developing countries. Assistance for the development of relevant research and development facilities and skills are of crucial importance for sustained efforts in this regard. Assistance will also be needed to establish test facilities for materials, components and systems of advanced fossil fuel technologies. Some of these advanced technologies such as fuel cells, hydrogen systems, and integrated systems that produce heat, electricity, chemicals and other products in what is called polyproduction, are still at a developmental stage and therefore the involvement of developing-country partners would promote their adoption upon maturity of the technology. The promotion of joint research constitutes both an effective way of building capacity and an option for the transfer of technology.

Options and strategies for international and regional cooperation

57. Minimizing the risk of climate change calls for long-term collaboration between industrialized and developing nations in advanced fossil energy technologies, including capacity-building and technology transfer. Such technology transfer will be essential to the efforts of donor Governments and international organizations to mitigate environmental problems. Currently, shorter-term considerations of the market appear to be taking precedence, with the result that turnkey deployment of existing energy technologies is taking place in the developing world. The first steps are to create greater awareness of the benefits that such technologies could bring and to assess their applicability and effectiveness under the diverse situations obtaining in developing countries in comparison with other alternatives. Partnership with developing countries in the development and deployment of advanced fossil fuel technologies is an option that would better serve markets for these technologies. An internationally coordinated approach to the dissemination of objectively assembled and relevant information on mature technologies would be beneficial to this end. Therefore, the challenge of global climate change and actions aimed at its mitigation will require enhanced international cooperation to help developing countries make substantial contributions to the shift towards cleaner fossil energy technologies.

E. Nuclear energy technologies

58. Nuclear power currently provides some 16 per cent of global electricity supply. Generating baseload electricity for more than 35 years, nuclear power has also accounted for most of the reduction in the carbon intensity per unit of delivered energy in OECD countries, and through the use of nuclear power the emission of significant amounts of CO_2, particulate matter, SO_2, nitrous oxide and volatile organic compounds has been avoided.

59. Nuclear power has its advantages and disadvantages, like all other electricity generating technologies. However, associated with nuclear power are a number of problems that are perceived as serious risks by the general public in many countries. Therefore, the development of cost-effective solutions to these problems and the achievement of public confidence in these solutions will determine the extent to which nuclear energy technologies will be able to contribute to a sustainable energy future.

60. On the other hand, there is a nuclear power stalemate in many regions, in part because the technology is much more costly than was originally projected. In many countries, nuclear power is perceived as too high an economic risk today by

private and public sector investors, and as a serious safety risk by civil society. As a result, the trend is towards moving away from nuclear power in these countries. Nevertheless, nuclear power continues to be of strong interest in a number of Asian countries and countries undergoing economic reform, even where financial resources are limited.

Challenges facing nuclear energy technologies

61. *Nuclear safety*. The challenge is to ensure the safe operation of the reactors existing in many countries under the pressure of economic competitiveness. The framework governing the safety of nuclear installations comprises: (a) legislative and regulatory arrangements at the national level complemented by a broad spectrum of mechanisms for international cooperation; (b) a set of non-binding international safety standards prepared by the International Atomic Energy Agency (IAEA), which serves as an international reference; (c) peer reviews by international teams of experts on the safety of installations based on these standards; and (d) legally binding instruments such as the Convention on Nuclear Safety.[6]

62. *Spent fuel and waste management*. Management of spent fuel and waste management constitute a crucial and sensitive issue, with public acceptance of options being of critical importance. High-level radioactive waste is produced when spent fuel is reprocessed to recover uranium and plutonium for recycling as reactor fuel. Some countries do not reprocess spent fuel but plan for its direct disposal. Part of the scientific and technical community is of the opinion that geologic disposal, using a system of engineered and natural barriers, can be carried out safely in stable geologic formations. However, site selection is a major public acceptance issue in all countries developing such facilities and no such facility has yet been authorized. For the time being, most high-level waste from commercial nuclear power is either stored on-site or transported to interim storage sites.

63. *Proliferation of fissile material*. At present, some 900 nuclear-related facilities are under IAEA safeguards, including power reactor facilities, fuel fabrication plants, and reprocessing and enrichment plants. With such a large and possibly growing number of nuclear power-related facilities, the challenge is to curb the potential nuclear power link to weapons proliferation by implementing effective and efficient safeguards.

Options and strategies to improve nuclear energy technologies

64. *Nuclear safety*. Options are represented by the adoption of new designs that have been developed where improved safety results from making use of modern control technology, from simplifying safety systems, and from introducing passive safety features requiring less human interaction. "Risk-informed decision-making" focuses on: (a) priority safety issues; (b) the transition to new designs that would meet the objective of the practical elimination of accident sequences leading to a significant release of radioactivity and would limit accident impacts to the plant site; and (c) the introduction of innovative designs based on passive safety features that demonstrate that certain safety systems required for existing reactors are no longer needed for protecting public health and safety.

65. *Spent fuel and waste management*. Several industrialized countries are currently engaged in studies of deep geologic disposal in order to demonstrate technologies for safely disposing of high-level waste and spent nuclear fuel. Options in this regard include further national efforts supplemented by IAEA activities, such as facilitating early entry into force of the legally binding Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management,[7] and fostering cooperative research on scientific issues related to the engineered and natural barriers for waste isolation.

66. *Proliferation of fissile material*. The Treaty on the Non-Proliferation of Nuclear Weapons,[8] signed in 1970 and extended indefinitely in 1995, is at the centre of the international non-proliferation regime. At present, 187 States have signed the Treaty, including 182 States that do not possess nuclear weapons, and the five States that had tested nuclear weapons before the Treaty came into force. The international community has entrusted IAEA with the authority to safeguard nuclear facilities. Treaties other than the Treaty on the Non-Proliferation of Nuclear Weapons focus on preventing the misuse of nuclear materials as well as the establishment of new nuclear-weapon-free zones in many parts of the world. Technology strategies to complement IAEA safeguards under consideration include the development of proliferation-resistant

nuclear power technologies and fuel cycles. The effective and efficient implementation of safeguards would greatly benefit from fuel cycles that take better account of the verification requirements of IAEA safeguards.

Actions relevant to overarching issues

67. With regard to nuclear safety, actions needed include: (a) intensifying efforts that are under way to improve the effectiveness and efficiency of the regulatory bodies by streamlining standards and regulations, and licensing processes; (b) exploring modern tools like "risk-informed regulations" and "safety indicators"; (c) prioritizing inspection and enforcement activities; and (d) enhancing the quality assurance process in the regulatory bodies themselves. A clear separation of the regulatory bodies from bodies responsible for promoting nuclear energy improves transparency and credibility. With regard to spent fuel and waste management, countries with small nuclear programmes, or fragile economies, often lack the resources to develop geologic repositories. Actions that would be needed include efforts by IAEA to provide a forum for technology transfer from the larger industrialized countries to such countries by: (a) sponsoring and coordinating research, (b) preparing documents on state-of-the-art technologies and (c) organizing international cooperative projects.

Options and strategies for international and regional cooperation

68. *Nuclear safety*. Intensifying international cooperation can support national efforts, harmonize safety requirements across countries and thereby ease licensing, promote a high level of nuclear safety worldwide, and improve the transparency in nuclear safety-related decisions. The mandate to establish safety standards and to provide for their application, including providing expert advice and peer (safety) review services, rests with IAEA. At the industrial level, the World Association of Nuclear Operators (WANO) fosters safety self-assessments and peer reviews. Strengthened international cooperation in technology research, development and demonstration could lead to consensus on safety requirements, agreements on technical solutions, and the sharing of research results. Other measures include: (a) strengthening the international peer safety review mechanism; (b) promoting self-assessments and learning from international experience, such as through the Incident Reporting System jointly operated by IAEA and the Nuclear Energy Agency (NEA) of OECD; (c) developing an internationally adopted set of safety indicators; and (d) increasing transparency in nuclear safety.

69. *Spent fuel and waste management*. A technology being considered for the future management of high-level waste is the partitioning of the long-lived radionuclides and their transmutation to shorter half-life radionuclides in accelerators or specially designed reactors. This technology has yet to be developed and costs are likely to be high, but it is of interest to countries planning to reprocess spent fuel to recover the maximum energy from uranium fuel by recycling the recovered plutonium. IAEA as well as NEA and the Commission of the European Communities has programmes in place to transfer technology and provide forums for international information exchange.

70. *Proliferation of fissile material*. As the response to weapons proliferation has to be a political one, international cooperation is critical to ensuring an effective barrier against proliferation. IAEA safeguard activities have to complement and interact with other components of the international non-proliferation regime, such as export control of nuclear and nuclear-related material and equipment, nuclear non-proliferation and disarmament treaties including nuclear-weapon-free zones, the control of illicit trafficking of nuclear material, physical protection of nuclear material, and the assessment of existing and innovative fuel cycles.

F. Rural energy

71. Although there is a growing recognition of the importance of an integrated approach to rural development, and of the linkages among energy, agriculture and environment, efforts at finding the most appropriate solution to the energy problems of rural areas are hampered by insufficient attention to rural development in general, and to rural energy needs in particular.

72. Meeting the energy needs of poor and dispersed rural communities with targeted actions is a major challenge. Rural energy problems vary from country to country both in magnitude and in scale. These problems are intertwined with many aspects of rural

life, which is characterized by sociocultural, traditional, agrarian and non-commercial factors that are often distinctly different from those in urban areas, and thus appear to be particularly daunting. Therefore, the challenge to improving the rural energy situation, including modernization of rural energy services, lies in: (a) securing a policy priority at the national level for rural energy modernization and removing urban bias; (b) improving access in rural areas to commercial liquid and gaseous fuels; (c) enlarging energy choices for basic needs, such as cooking and lighting; (d) promoting diverse options for rural electrification, including decentralized systems; (e) developing rural energy markets; (f) financing decentralized energy systems; (g) improving service and maintenance skills; and (h) integrating energy advances with other aspects of rural development.

Options and strategies to improve the rural energy situation

73. Options available to developing countries to address rural energy problems cover: (a) improving the quality and quantity of information on the availability and use of energy from all sources in rural areas for use by policy makers; (b) integrating energy policies into overall rural development strategies with emphasis on income-generation; (c) initiating and/or strengthening rural development policies, including the elimination of bias towards urban development; (d) establishing a high priority for the provision of electricity in a cost-effective manner to unserved rural populations; (e) promoting sustained programmes of investment in decentralized energy schemes based on renewable energy for rural areas not connected to grids, wherever such schemes are cost-effective; (f) adopting rational pricing of energy to encourage conservation and efficient use; (g) removing, in phases, subsidies and/or poorly designed price controls; (h) introducing innovative financing arrangements in rural areas, especially for low-income inhabitants, such as microfinancing and cooperative arrangements with credit and licensing agreements to encourage the private sector to provide certain energy services in rural areas; (i) raising awareness and educating consumers about the advantages of renewable energy technologies by utilizing and/or strengthening existing extension programmes; (j) disseminating information; and (k) enhancing skill and training.

Actions relevant to overarching issues

74. In order to build human resource capacities in this field in rural areas, inter alia, within community-based organizations and non-governmental organizations, targeted actions are needed that cover: (a) information resources; (b) participatory approaches; (c) organizational support; (d) concrete energy development activities involving appropriate technologies, the provision of programme tools and guidance material for effective management; (e) training to improve repair and maintenance skills; (f) entrepreneurial capacity development; (g) the facilitation of local manufacture; and (h) the establishment of credit facilities and support for self-reliant local institutions, and networking arrangements. Actions are also needed in the area of institutional reform to promote the modernization of rural energy services and to accelerate rural electrification employing grid-based and decentralized options.

Options for international and regional cooperation

75. At the regional level, given that similar conditions often exist with regard to rural energy in many countries, much can be gained through cooperation in exchanging information and experiences about rural energy programmes. Support for suitable programmes of action in the work programmes of the regional commissions is an option that could achieve this objective.

76. Options that can be developed, based on the experience gained so far, include international cooperation programmes for modernizing rural electrification employing new and innovative approaches such as distributed generation, solar home systems, and biomass-based rural power schemes linked to agriculture and rural industries. These programmes can be directed towards establishing forward and backward linkages with rural development programmes that seek to promote participatory approaches.

77. At the regional and international levels, assistance programmes for the development of rural energy services may be considered, as well as technical assistance in establishing entrepreneurial capacities, and financing arrangements including microcredit schemes specifically for the provision of energy services.

G. Energy and transportation

78. Activity in the transport sector is highly correlated to economic activity in general, and this relationship is especially apparent in trends during the last half of the twentieth century in industrialized countries. In OECD countries, the transport sector accounts for between 2 and 4 per cent of total employment, and between 4 and 8 per cent of GDP. Fifteen per cent of total household expenditures in these countries are channelled to the transport sector.

79. The near-total reliance of the transportation sector on petroleum has resulted in this sector's using more than 60 per cent of all petroleum consumed worldwide. Demand for transport services is expected to increase in industrialized and developing countries alike, though growth in motor vehicle registration in industrialized countries appears to have slowed somewhat in recent years. Developing countries are expected to record significant increases in the demand for transport services and, in a business-as-usual scenario, will satisfy a significant portion of this demand with passenger vehicles. During the 25 years following 1970, the annual growth rate of total passenger vehicles in such low-gross national product (GNP) countries as China, Egypt and Pakistan was 11.2, 9.4 and 7.2 per cent, respectively, while in the higher-GNP countries, Canada, France, the United Kingdom of Great Britain and Northern Ireland and the United States of America, the annual growth rate was 2.9, 2.7, 2.5 and 2.0 per cent, respectively, although the increases for the higher-GNP countries, compared with the increases for the low-GNP countries, obviously corresponded to a greater number of vehicles.

80. The transport sector is responsible for producing emissions of particulate matter, nitrogen oxides (NO_x), carbon monoxide (CO) and volatile organic compounds at the local and regional levels, as well as for having adverse noise and land-use impacts. It is also a major contributor to global emissions of a major greenhouse gas, CO_2, which is the major component of vehicle exhaust. CO_2 emissions originating from the transport sector continue to grow more rapidly than those from other fossil fuel-using sectors. Further discussion of these issues can be found in the report of the Secretary-General on the protection of the atmosphere (E/CN.17/2001/2) and on transport (E/CN.17/2001/3) submitted for consideration by the Inter-sessional Ad Hoc Working Group of the ninth session of the Commission on Sustainable Development.

Challenges facing energy and transportation

81. Challenges facing energy-related issues in transportation include: (a) the paucity of information on energy efficiencies, emissions and the impacts of different options; (b) the lack of awareness of energy efficient transportation options; (c) the lack of coherent policies linking energy and transportation; (d) the poor transport infrastructure which is not energy-efficient; (e) the lack of incentives to develop and promote cost-effective, more efficient and less polluting transport systems; (f) the barriers to acquisition and adaptation of efficient transport technologies; and (g) the slow pace of the shift to transport modes that minimize adverse effects on the atmosphere.

Options to improve energy efficiency and minimize emissions in transportation

82. The options available in terms of alternative transportation fuels that have attracted the most interest and are being actively tested and developed are: natural gas, electricity, liquefied petroleum gas, methanol, ethanol, rapeseed oil methyl ester and hydrogen. Passenger vehicles offer the greatest opportunity for improving energy efficiency and reducing environmental impacts using advanced technology and alternative fuels.

83. Technologies currently existing or under development to improve fuel economy, as well as those that are envisioned as possibilities for meeting future more stringent air quality regulations, include: (a) advanced conventional gasoline and diesel vehicles of various types, (b) electric vehicles, (c) fuel-cell based vehicles, (d) hybrid (internal combustion engine with an electric drivetrain) vehicles with batteries, (e) hybrid flywheel vehicles and (f) hybrid vehicles equipped with an ultra-high capacitance device. The potential fuel economy for these innovative technologies ranges from 22.4 to 30 kilometres per litre (km/l) (53.2 to 71.2 miles per US gallon (mpg)), which, for the current fuel economy of a mid-size automobile of 11.8 km/l (28 mpg), corresponds to increases ranging from 82 to 160 per cent. The additional cost to the consumer of each of these advanced technology passenger vehicles is estimated to range from approximately US$ 2,500 to almost US$ 11,000, rendering such advanced technologies, many of which

are likely to be feasible options in industrialized countries in the next 15 years, unaffordable for most developing countries. A limitation on emission reduction is the slow rate of adoption, in countries with developing and transitional economies as well as in many industrialized countries, of the catalytic converter, an available technology that greatly reduces tailpipe emissions at a modest increase in vehicle purchase price.

84. Technology options that can be considered for addressing the environmental impacts are: (a) improved performance of internal combustion engines and controls on motor vehicle emissions through the use of cleaner fuels, namely, lead- and sulphur-free gasoline; (b) fuel additives to reduce pollution; and (c) catalytic converters to reduce tailpipe emissions of various gaseous pollutants. In the long term, the large-scale replacement of the current petroleum-based transportation system by a system using fuels derived entirely from renewable sources of energy, including hydrogen from the electrolysis of water and electric vehicles powered by electricity from non-fossil energy sources and fuel cell vehicles, could result in a reduction of greenhouse gas emissions from vehicular transportation of over 80 per cent. In order to increase the adoption of these systems, market instruments, such as fiscal incentives and regulations, and other measures are needed to support the establishment of the infrastructure necessary to provide convenient alternative refuelling facilities.

Actions relevant to overarching issues

85. Partnerships at the national level are an option for strengthening transport infrastructures and developing innovative mass transport schemes. There are a number of policy options for reducing the negative environmental and social impacts of transportation, including measures to: (a) rationalize demand; (b) encourage transportation mode changes; (c) raise the energy efficiency of each transportation mode; (d) promote the use of alternative fuels; and (e) integrate urban planning and transportation planning.

Options and strategies for international and regional cooperation

86. With the developing countries in the process or on the threshold of rapid motorization, cooperation at the international level would help to achieve tangible mitigation of adverse impacts on human health and productivity, and environmental quality from transport-related activities, especially in urban centres where vehicle emissions are a significant source of urban air quality problems. A programme of action targeted at several major cities in the various regions of the developing world, with a view to developing blueprints for implementing the measures identified above, should be developed with international collaboration among city authorities, urban planners, and bilateral and multilateral sources of finance. An example of an effective programme of action is the newly operational "Promoting Sustainable Transport" programme introduced by the GEF, the objective of which is to reduce the risk of climate change by reducing net greenhouse gas emissions from transportation through both emission reduction and enhancement of the removal of such gases by sinks.

III. Options for strengthening regional and international cooperation

87. The foregoing discussion reveals that resolution of the energy issues confronting the world today is not only a technical challenge. The issues involved are complex because of their social, political, economic and environmental dimensions. Achieving social harmony and maintaining social stability are key challenges in many countries, even while they confront their energy challenges. Therefore, consensus is required on how best to address the challenges through common endeavours in order to achieve the goals of energy for sustainable development.

88. Given the scale and magnitude of energy challenges that continue to be experienced by developing countries, today there is greater need for international cooperation in energy than ever before if tangible progress is to be made in achieving the goals of sustainability. The United Nations system as a whole has been involved with energy-sector cooperation assistance to developing countries for several decades. However, there remains considerable scope for achieving more effective coordination and harmonization of activities within the United Nations system that promote energy for sustainable development.

89. In addition to the ongoing efforts of the United Nations system aimed at promoting sustainable energy, new initiatives are needed to intensify international

cooperation to mobilize investments in energy for sustainable development, for building effective public-private partnerships, and for strengthening capacities in developing countries to sustain such partnerships. There is also need for appropriate mechanisms to promote cooperation, both North-South and South-South. Finally, it is incumbent upon the international community to assist the least developed countries in obtaining the energy they need for sustainable development at prices they can afford.

90. Options for strengthening regional and international cooperation including coordination within the United Nations system are addressed below. These options are presented for the purpose of facilitating further discussions on frameworks for regional and international cooperation; the list of the options that could be considered is intended to be indicative, rather than exhaustive. Many of the options have far-reaching political, financial and organizational implications.

A. Strengthening the existing arrangement for coordination of the United Nations system response to the need to promote sustainable energy development and its implementation

91. An ad hoc mechanism already exists in the United Nations system for the coordination of its activities in the field of energy in the form of the Ad hoc Inter-Agency Task Force on Energy, a subsidiary body of the Inter-Agency Committee on Sustainable Development (IACSD). The Task Force is chaired by the Department of Economic and Social Affairs of the United Nations Secretariat and meets three to four times per year. One option would be to utilize this mechanism more effectively by improving its mandate, and its functioning and removing the restriction on its ad hoc and time-bound status. Within this framework, individual entities of the United Nations system might be identified as task managers for specific aspects of energy. A noteworthy feature of this option is that it could provide better linkages with the Commission on Sustainable Development and fulfil the need for a focal point within the United Nations system for better coordination and harmonization of action programmes on energy for sustainable development without resorting to a new institutional mechanism.

B. Establishing the forum for a global dialogue involving producers and consumers of energy and other relevant stakeholders

92. The need for a regular dialogue on energy security and market stability has been noted. A United Nations-sponsored world energy forum modelled on the World Economic Forum held annually in Davos, Switzerland, could be an option to bring together heads of Government, leaders from the energy industry including the major oil companies, and the leaders of such organizations as the World Bank, the regional development banks, OPEC, the International Energy Agency (IEA) of OECD, the Asia-Pacific Economic Cooperation (APEC), the Latin American Energy Organization (OLADE), the Association of Southeast Asian Nations (ASEAN), the South Asian Association for Regional Cooperation (SAARC), business councils, chambers of commerce, commercial banks, academic and research institutions, independent power producers, the legal community and non-governmental organizations. By bringing together key leaders, such an initiative might provide a useful forum within which, through dialogue and engagement, to expedite action in key areas that could contribute to greater energy security through market stability and to explore mutually beneficial opportunities for investment in sustainable energy.

C. Establishing energy charters and treaties

93. Experience in Europe indicates that energy charters and treaties can contribute, inter alia, to greater regional energy security and facilitate cross-boundary energy trade, grid interconnections, and arrangements for regional energy storage. This is an option that could be considered, with suitable adaptations, for other regions as well.

D. Expanding the World Solar Programme into a world sustainable energy programme

94. One of the ways in which increased global cooperation might be sought to promote energy for sustainable development is through enlarging the

World Solar Programme into a world sustainable energy programme. The World Solar Programme is a United Nations Educational, Scientific and Cultural Organization (UNESCO)-led initiative that was the outcome of the World Solar Summit, which also established a World Solar Commission. In its resolution 54/215 of 22 December 1999, the General Assembly recalled its resolution 53/7 of 16 October 1998 by which it, inter alia, had endorsed the World Solar Programme 1996-2005 as a contribution to the overall sustainable development agenda, and called for further action to ensure that this programme was fully integrated into and brought into the mainstream of the efforts of the United Nations towards attaining the objective of sustainable development. Therefore, the feasibility of this option may be considered in the context of that resolution.

E. Establishing a Global Environment Facility (GEF)-type mechanism for energy for sustainable development

95. The GEF currently serves as a financial mechanism that responds to the needs of the Convention on Biological Diversity[9] and the United Nations Framework Convention on Climate Change.[10] It also provides operational guidance for international waters and ozone activities, the latter consistent with the Montreal Protocol on Substances that Deplete the Ozone Layer and its amendments. In dealing with energy as a climate change issue, the GEF provides financial support in the form of incremental costs to developing countries for environmentally sound energy-related projects and programmes. As energy is also linked to other major global issues including poverty, equity, health and gender, one of the options to consider is the establishment of a mechanism for energy for sustainable development using a GEF-type mechanism that goes beyond the notion of incremental costs. A separate global sustainable energy facility for supporting programmes on energy for sustainable development and for assisting in building the requisite capacity could be an option for consideration.

F. Organizing an annual global meeting on financing energy for sustainable development

96. ODA remains a significant source of external funding for many developing countries. It plays an important complementary and catalytic role in promoting sustainable development. To this end, there is need for industrialized countries to fulfil their commitment to reach the targets agreed at the United Nations Conference on Environment and Development, part of which can be used by recipient countries to address energy and related problems. At the same time, there is need for multilateral financial institutions to increase their funding, inter alia, through concessional mechanisms to developing countries, to support their efforts in promoting energy for sustainable development. In addition, there is a need to mobilize private capital for investment in these areas. Of crucial importance is the requirement that developing countries create a favourable climate for donor support and increased investment through the establishment of policies, and legal and regulatory provisions. Sources that can be explored in this regard comprise: (a) international financing resulting from compliance with agreed targets for ODA, enhanced foreign capital flows and debt alleviation; (b) domestic financing through economic instruments, subsidy reform and private sector investment; and (c) innovative national and international financing, including joint implementation schemes, internationally tradable permits, the proposed clean development mechanism, and consortia for financing energy for sustainable development.

G. Using the proposed clean development mechanisms as a vehicle for sustainable energy with a special focus on intensification of renewable energy utilization

97. Alongside the efforts to shape the proposed clean development mechanism into effective instruments for channelling investments into developing countries for promoting cleaner fossil energy systems, one of the options that could be considered is to build into such mechanisms a distinct role for renewable energy and thereby enhance the scope for investments in renewable energy applications.

H. Establishing revolving funds and financing arrangements

98. The establishment of revolving funds and microcredit facilities is an option that can respond to the credit needs of the poor especially in rural areas, not only for basic energy needs, but also for improving their quality of life. Support is needed for strengthening the institutional capacity at local levels. International initiatives can play a catalytic role in helping to effect the sharing of experiences in participatory approaches and by seeding community-based initiatives at the local level in support of energy activities for sustainable development. Donor support could strengthen national efforts in this regard.

I. Launching an initiative to improve access to cleaner fuels by the least developed countries

99. One of the options that could be considered for finding ways of alleviating the serious energy supply problems faced by the least developed countries is to improve their access to cleaner fuels by targeting the development of domestic natural gas resources. As the least greenhouse gas-emitting of the fossil fuels and one that is very flexible for all uses, natural gas would be the focus of an international effort to provide energy security for the poorest countries. The launching of a natural gas exploration and development initiative for the least developed countries through the establishment of a revolving fund is an option that could jump-start development efforts by those countries. In order to attract risk capital and investments from transnational oil and gas corporations, OPEC, the Group of Eight (G-8) nations, the World Bank, the regional development banks and foundations could be invited to contribute to a revolving fund as a commitment to helping the poorest nations improve their accessibility to clean energy for development.

J. Establishing a network of Consultative Group on International Agricultural Research (CGIAR)-type centres of excellence

100. Linking the reputable national energy centres established in many countries into a network focusing on energy technologies for sustainable development could facilitate greater interaction among them, which might enable countries to learn from each other and thereby optimize their collective effort and avoid duplication where possible. This option provides a forum for North-South and South-South collaborations in the energy field, and could also help in establishing standards and best p' ctices, thereby contributing to greater diffusion of sustainable energy technologies. The successful model of the Consultative Group on International Agricultural Research (CGIAR) could provide guidance in this regard. As part of such a global network, cooperative arrangements such as "twinning" between selected institutions in industrialized and developing countries could be explored for the purpose of strengthening research and development capacities in the latter group of countries which could lead to joint programmes.

K. Launching an international training initiative for capacity-building

101. A key aspect of capacity-building in the field of energy is the need for enhancement of skills not only for policy formulation but also for its effective implementation. International support is needed for building institutional and human resource capacities for energy for sustainable development. The establishment of sustainable energy training centres, either as extensions of existing energy sector institutions or as new entities at the national and regional levels, could be an option for the intensification of efforts in this regard. An international training centre for sustainable energy is another option that could serve as a focal point for supporting efforts to promote energy for sustainable development through training.

L. Establishing an international energy information centre or clearing house

102. There are currently numerous energy information sources, such as the United Nations Statistics Division, IEA, IAEA, the United States Energy Information Office, the Tata Energy Research Institute, the World Energy Council and the United States National Renewable Energy Laboratory, yet accessibility to and availability of relevant information on experiences of countries relating to energy for sustainable development continue to need further improvement.

One of the options that could be considered is the establishment of an international energy information centre or clearing house that could also support and promote capacity-building activities in this area.

M. Establishing international cooperation programmes for promoting public-private partnerships for technology transfer

103. Options that could be considered for promoting the next generation of energy-efficient technologies include initiatives in the form of international partnership programmes involving public and private entities, along the lines of the recently initiated Global Compact. Such a participatory approach with cost-sharing arrangements can be an option for transfer and adaptation of such next-generation technologies as cleaner fossil fuel technologies, fuel cells, solar power systems, decentralized energy systems, and new transportation systems.

N. Launching market transformation initiatives for energy systems for sustainable development with a focus on rural areas and rural electrification

104. Given that market mechanisms play a vital role in the diffusion of energy technologies, one of the options that can be considered is to build on the experience gained from such initiatives as the Photovoltaic Market Transformation Initiative of the World Bank and expand it so as to cover all decentralized energy systems, including mini-grid rural electrification schemes. Such an initiative could take the form of a decentralized energy market transformation initiative.

O. Establishing regional energy organizations

105. One of the options that could be considered for enhancing regional cooperation in energy is the promotion of regional energy organizations, similar to OLADE for Latin America and IEA for OECD countries, in other regions that currently do not have such arrangements. Such cooperation could be of particularly valuable assistance to the nascent African Energy Commission.

IV. Conclusions

106. Energy for sustainable development continues to face many challenges that call for dialogue and actions at the national, regional and international levels. The challenge of sustainability calls for an inclusive and integrated approach involving all relevant stakeholders. Options and strategies need to take into account the diversity that exists in country situations. There is need to strengthen existing mechanisms and the roles of multilateral organizations for regional and international cooperation, as well as to explore new and innovative approaches to the mobilization of financial resources for supporting energy for sustainable development in developing countries. Urgent attention is needed to refocus assistance in order to build the requisite capacity in developing countries to promote energy for sustainable development.

Notes

[1] *Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992*, vol. I, *Resolutions Adopted by the Conference* (United Nations publication, Sales No. E.93.I.8 and corrigendum), resolution 1, annex II.

[2] General Assembly resolution S-19/2, annex, para. 46 (a).

[3] Ibid., annex, appendix.

[4] Ibid., annex, para. 46 (a).

[5] General Assembly resolution S-19/2, annex.

[6] International Atomic Energy Agency, INFCIRC/449.

[7] See International Atomic Energy Agency document GOV/INF/821-GC(41)/INF/12, appendix I.

[8] United Nations, *Treaty Series*, vol. 729, No. 10485.

[9] See United Nations Environment Programme, *Convention on Biological Diversity* (Environmental Law and Institution Programme Activity Centre), June 1992.

[10] A/AC.237/18 (Part II)/Add.1 and Corr.1, annex I.